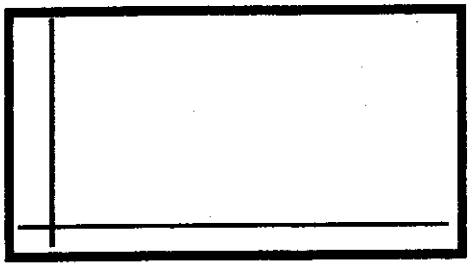
Data Collection Activity - Damped Harmonic Motion

Introduction: In this activity a paper plate is suspended by a slinky above the floor. The slinky is stretched and then released. You will find a mathematical model which represents the relationship between the distance from the paper plate to the floor with respect to time over a 5 second period.

1. After receiving the data and making a scatterplot on your calculator, make a drawing of the scatterplot below and state the **WINDOW**.



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2. Enter the general form of the sinusoidal function (a cosine function) into **Y1** of your calculator.

Y1 = Acos(B(x - C)) + D (Use your ALPHA key to get the letters **A, B, C,** and **D.**)

Turn off **Y1** (and make sure you are in **Radian** mode).

3. Remember, the value of **A** determines the _____, the value of **B** effects the _____, the value of **C** determines the _____, and **D** the _____.

4.Let's find the values of **A, B, C,** and **D** for this particular "damped" sinusoid.

Start with **B. TRACE** to find the **time** of the first maximum and the last maximum of your data points. Record the values below and find the difference between the two.

First max occurs at t= _____ Last max occurs at t= _____ Difference: _____

How many periods of the function does this represent? _____

Divide the difference recorded above by the number of periods to get the average period length.

Average period length is _____ .

Use this value to find **B** of your function. **B=** _____.

On the **HOME** screen of your calculator, **STORE** this value in **B.** (__→B)

Now find **C.** Again, record the time of the first maximum. _____ This should be a good estimate of the phase shift of your function. **STORE** this value in **C.**

Now find **D.** The vertical shift is usually the average of the maximum and minimum values of the sinusoid but since the maximums (and minimums) are not constant, this is a little more complicated. First find the **average** of two consecutive maximums. _____. Now, take this value and average it with the minimum which is between the two maximums. _____

To see if this value is the correct vertical shift, place it in **Y2** and graph it with your data points. Hopefully it should represent the "midline" of your data. If it does, **STORE** this value in **D**.

To see how we've done so far (finding values of **B, C,** and **D**) let's find a "preliminary" value of **A** and graph our function. Let's use the first maximum to determine an amplitude. Find the first maximum value by tracing. First maximum value is _____.
The amplitude **A** will equal this maximum minus the value of **D**. **A** = _____.
STORE this value in **A**. (Note: This is the amplitude of a sinusoid that is <u>not</u> decreasing like ours is.)

Turn on **Y1** and graph it. Everything should fit your data except the amplitude after the first max! If it does not, now is the time to find your mistake!

5. Now we need to find the "decay" of our amplitude. Our value of **A** is not a constant but an **exponential function**. Trace on the scatterplot and record the coordinates of the <u>maximums</u> in the chart below.

Time						
Height						

Enter the coordinates of the x-values (Time) in **L3** and the y-values (Height) in **L4**. Now we need to turn the y-values into amplitude values by subtracting **D** from the **L4** values. (With your cursor on top of **L4** type in **L4 - D** on the entry line.) This brings the shift back down and the y-values now represent amplitude values.

6. Run an **exponential regression** on the values in **L3** and **L4**. Record the equation below.

y = _____

7. Put this equation in **Y2**. Add **D** to this equation. Turn off **Y1** and graph the equation in **Y2**. Does the exponential function go through each of the maximum points? _____ If not, check to see what you did wrong.

8. Change the equation in **Y2** again by taking away (deleting) the **D** value. Substitute **Y2** (from **Y-VARS**) in for the **A** that is in **Y1**. Turn off **Y2** and graph the equation in **Y1**. How well does this graph fit your data points?

Explain._____

9. Record the final equation using the actual values of **B, C,** and **D**, and the equation in **Y2** (for A) below.

y = _____